

# PATENT SPECIFICATION

(11) 1 309 424

## DRAWINGS ATTACHED

- (21) Application No. 11575/70 (22) Filed 11 March 1970  
 (44) Complete Specification published 14 March 1973  
 (51) International Classification G01F 11/10; B29C 11/00 // G01F 11/24, 1/16, 1/24, 1/26, 37/14, 37/02, 37/20  
 (52) Index at acceptance  
     B8N 6B1A 6B1B3A 6B1B3B 6B2  
     B5A 1B1A1 1K2A1B 2D1X 2F11  
     B8C 10B2C2 10B2E 10B2F1 10BB2D1 10E 10H3 10Q 1C2B  
 (72) Inventor THEODORE F. ARONSON



## (54) METHOD OF AND APPARATUS FOR MEASURING AND DISPENSING PREDETERMINED AMOUNTS OF POWDERED MATERIAL

(71) We, PERRY INDUSTRIES, INC. a Delaware corporation, U.S.A. of 121 New South Road, Hicksville, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of and apparatus for measuring and dispensing predetermined amounts of a powdered material.

Optimum measuring and dispensing of powdered material into containers involve many different considerations as, for example, production rate, fill accuracy, freedom from dusting, final conditioning of the powder, physical characteristics of the powder, size and shape of the container, and its opening, among others. One of the primary considerations in dispensing and handling of powdered material is the "fill accuracy", that is, how close to the actual required weight and specifications a given powdered material can be consistently and positively measured and dispensed. The "fill accuracy" factor becomes especially critical in the measuring and dispensing of powdered materials as, for example, medicinal drugs, propellant or explosive-type powders, and other powdered materials wherein the precision of the measured charge or dose is not only a function of the cost of the product, but also a critical basic control consideration in the final assembly of a product in which the measured powder charge constitutes but a part.

Another important consideration in any powder filling and dispensing operation is attaining freedom of dust contamination of the atmosphere, of the container, and/or of the machinery effecting the measuring and dispensing operation. Analogous to this problem of dusting is the further consideration of de-

positing the powder charge into the final container, and the final form which the powder charge is required to take in the container. For example, some powder charges disposed within a container need be only contained in loose or fluffy state, such as talcum powders. Other powders may be required to be consolidated or compacted under specific pressures, as, for example, explosive powders when they are placed in a detonator cap or the like. Another important consideration in the handling of powdered materials as, for example, the explosive powders, is their sensitivity to pressure, abrasion and/or generated heat.

A powder may be a free-flowing powder which can be poured, as for example, dry sand. Otherwise defined, a free-flowing powder is one which forms a pile resembling a very flat cone when it is poured in a stream onto a horizontal surface. Typical free-flowing powders are coffee, granulated sugar, table salt, propellants whose particles are in the shape of balls, flakes or rods and other explosives which may be in the form of coarse granulars or the like.

A non free-flowing powder may be defined as that powdered material that will tend to bridge or arch when it is placed in a hopper or funnel unless special conditions such as vibration or aeration are made to occur. Generally non free-flowing powders will pack into a solid mass in a container under their own weight, or during vibration or transport. This category includes such materials as talcum powder, confectionery sugar, toners, propellants, such as fine black powder and explosives in very fine particle sizes. These particle sizes range from a high limit of 250-mesh and below.

Certain powders, regardless of their flow characteristics, may be classified also as sensitive powders, i.e. powders sensitive to abrasion, pressure or heat. Many powdered drugs meant

for ultimate use as injectibles are considered sensitive because they will tend to conglomerate or form clumps, if subjected to rough handling or pressure. Usually these clumps can not be dissolved or passed through a hypodermic needle. In the case of propellants and explosives, abrasion, pressure or heat may result in an incident of destroying the equipment or sections of it, and this factor becomes a prime overriding parameter in determining how such material can be best handled.

Heretofore, many systems and methods have been used in an effort to accurately measure and dispense predetermined amounts of various types of powdered material. However, each has its own limitations and disadvantages. For example, net weight fillers are extremely slow in operation.

The limitation of net weight fillers is that they are adapted primarily for weighing of free-flowing materials, as the principles on which the net weighers operate virtually negate their use in handling non-free-flowing or sticky powdered materials.

Another method heretofore used in handling various powders was the gravity volumetric type of filler. This is perhaps the simplest and least expensive of the known powder fillers. However, the simplest volumetric fillers are limited to free flowing powders and consist simply of pouring a powder into a container to a point of overflowing.

In hazardous powder filling operations a spoon or scoop is inserted into the powder supply and as it is withdrawn, the excess is doctored off to form a level scoop. The level scoop is then dropped into a funnel for transfer to the final container. However, any sticking of the powder to the scoop destroys any useful accuracy which can be obtained by this method.

Another method which has been employed in the past is that of auger feeding. However, the auger method has not found much favor in the loading of hazardous powders because of its inherent mode of operation. The auger method develops high pressure points in the auger tube as the auger rotates, as well as the unavoidable abrasion of the powder by the auger surface, and between the auger edges and the inside walls of the auger tube. Utilization of the auger feeder on insensitive materials, such as drugs and toners has, in the past, also resulted in the formulation of conglomerates due to the heat and pressure generated by the system.

Another method which has been used is the control rate of flow fillings. This is a simple free-flow filler that has usually been considered one of the least accurate types of powder fillers. However, this system is subject to the disadvantages of dusting, inaccuracies due to density variations and flow rate characteristics of the powder, and that the execution of this approach usually results in a rather complex

and expensively machined apparatus whose accuracy reliability is always uncertain. Also, such control rate of flow fillers are limited to those powders or mixtures which must have not only extremely good flow characteristics but also must have the consistency of this same characteristic.

Vacuum container volumetric filler has been another system tried to effect optimum filling results. However, the disadvantages of this system in some applications is the fact that the fill weight is affected by variations in the volumes of successive containers.

Thus, in the past considerable difficulty had been noted in attempts to get uniform charges of powdered material at required production rates which would consistently measure and dispense powders to meet specific tolerances. In the field of handling and filling powdered drugs, pharmaceuticals and explosive powders into their respective containers, it is absolutely essential that precise dosages be attained with a maximum degree of certainty and reliability. Also many powders, as for example, various explosive powders, in their final deposited form, have to be consolidated to approximately ten thousand to twenty thousand p.s.i. before subsequent charges are placed or operation performed. In many of the known methods and systems of powder filling, air is entrapped by the powdered material so that the powder in its normal fill density results in a volume which may overflow the container into which the powdered material is to be confined. In such events it was necessary to place into use a funnel means which sealed to the top of the container, the funnel being provided with circumscribing wall portions corresponding in size to the inside diameter of the container. Thus, the given quantity of powder in its loose form is confined to the container adapted to contain it and the connected funnel, whereupon a consolidating ram is thereafter used to compress the quantity of powder into the container. However, such method of filling containers with powdered material and more particularly, with explosive powders, increased the danger of explosion and fire incidental to the inherent friction and abrasion occurring between the ram diameter, and the walls of the funnel and connected container during the compressing operation. As such powder in loose form tends to coat the funnel and the sides of the containers, the danger of explosion is further enhanced as the ram descends to compress the powder.

According to one aspect of the present invention, there is provided an apparatus for measuring and dispensing predetermined amounts of powdered material, comprising a measuring chamber having an open end, a piston including a piston head disposed within the chamber, said piston head being pervious to a gaseous medium and impervious to the powdered material, vacuum means to subject

the measuring chamber to a negative pressure through the piston head during charging of a predetermined measured amount of powdered material into the chamber, means to effect relative movement between the chamber and the piston head to eject the powdered material charged into the chamber, and means for compacting the powdered material before or after charging of the measuring chamber to provide a slug within the measuring chamber.

In another aspect, the invention provides a method of measuring and dispensing a predetermined amount of powdered material, comprising the steps of: positioning an open end of a measuring chamber provided with a movable piston member adjacent to a supply of powdered material, charging the chamber with a predetermined measured amount of powdered material by subjecting the chamber to a negative pressure through a piston head of the piston member which is pervious to a gaseous medium and impervious to the powdered material, the powdered material being retained in the chamber by maintaining the negative pressure in the chamber, positioning the charged chamber in abutment with an anvil, effecting displacement of the piston head to compact the powdered material within the chamber between the anvil and the displaced piston to form a slug, and discharging the compacted slug of powdered material from the chamber by further displacement of the piston at a point removed from the anvil.

In removing the charged measuring chamber from the supply of powdered material, the end of the chamber may be doctored or dressed to remove any excess of powdered material which tends to adhere or extend beyond the measured volume of the chamber. In this manner an even volumetric charge of material is precisely retained in the measuring chamber at each measuring operation.

Positive separation of the slug of powdered material from the piston head may be accomplished by applying a stream of gas under positive pressure to the piston head. The result is that the slug is blown clearly and freely from the piston head. The pulse of gas acting on the piston head to separate the slug also functions to purge the piston head of any powdered material tending to adhere thereto, thereby ensuring that the accuracy of the measured charge is maintained throughout a series of successive measuring and dispensing operations.

In order that the invention may be readily understood, embodiments thereof will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a fragmentary side view of an apparatus embodying the present invention, partly in section along line 1—1 on Fig. 2.

Fig. 2 is a partly sectioned front view of a fragmentary portion of the apparatus disclosed in Fig. 1.

Fig. 3 is a schematic illustration of the apparatus of Figs. 1 and 2 showing the initial filling position of the measuring chamber.

Fig. 4 is a view similar to that of Fig. 3 but illustrating the relative position of the component parts illustrating further compaction of the powder charge within the measuring chamber.

Fig. 5 is a view similar to that of Figs. 3 and 4, but illustrating the compacted slug being discharged from the measuring chamber.

Fig. 6 is a view of a modified form of the apparatus shown in Figs. 1 to 5.

Fig. 7 is a view illustrating a bank of turret filling heads of the type shown in Fig. 6.

Fig. 8 is a diagrammatic illustration of the invention as applied to a measuring gun.

Fig. 9 illustrates diagrammatically the charging of the measuring gun with a predetermined volumetric amount of powdered material.

Fig. 10 illustrates diagrammatically the compaction of the volumetric charge of powdered material within the gun to attain a slug having a density greater than the initial evacuated density of the charged material.

Fig. 11 illustrates diagrammatically the metering or measuring gun in the discharging position thereof.

Fig. 12 illustrates diagrammatically the release of the compacted powdered slug from the end of the piston.

Fig. 13 illustrates a side elevation view of an apparatus in which automation of the metering gun principle as diagrammatically disclosed in Figs. 8 to 12 may be performed to expedite a production type of loading operation.

Fig. 14 is an enlarged fragmentary sectional side view of the apparatus of Fig. 13 having portion shown in section and in which the several positions of the metering gun are illustrated in dotted lines to illustrate the various positions thereof during a machine cycle.

Fig. 15 is an enlarged detail showing illustrating the end of the measuring gun inserted into a supply of bulk powdered material.

Fig. 16 is an enlarged detail illustration similar to Fig. 15 but illustrating a relative position of the parts upon withdrawal of the measuring gun from the bulk powder supply.

Fig. 17 is a view similar to that of Fig. 16 but illustrating the manner in which doctoring any excess of powdered material from the end of the measuring chamber is attained.

Fig. 18 illustrates the measuring gun in a fully retracted position from the powder supply.

Fig. 19 illustrates a detail sectional view of the metering gun of the apparatus of Figs. 13 and 14 in the charging station thereof.



Fig. 20 illustrates the metering gun charged with a powdered material, and doctored of excess material.

5 Fig. 21 illustrates the relative position of the metering gun parts in the compacting station of the apparatus.

Fig. 22 illustrates the arrangement of parts in a discharging station of the apparatus.

10 Fig. 23 is a plan view of the apparatus of Fig. 13.

Fig. 24 is a fragmentary detail showing of the gun mount of the apparatus of Fig. 13.

Fig. 25 is an enlarged detail view of the measuring chamber of Fig. 2.

15 Fig. 26 is a detail fragmentary showing of a modified turret filling head for minimizing the doctoring error.

Fig. 27 illustrates a diagrammatic showing of a modified form of doctoring means for use with a turret filling head.

20 Fig. 28 is a diagrammatic showing of another modification of doctoring means as used with a turret filling head.

25 Fig. 29 is yet another diagrammatic showing of still another modified form of doctoring means.

Fig. 30 is a diagrammatic showing of still another modified doctoring means.

30 Fig. 31 is a schematic showing of a modified embodiment for attaining uniform powder density.

Fig. 32 is a plan view of Fig. 31.

35 Fig. 33 is a modified meter gun formed with a tapered measuring chamber for reducing the exposed area of a given volume to a minimum to reduce doctoring error.

40 With the method and apparatus to be hereinafter described, almost any material of a powdered nature may be measured and dispensed with a maximum degree of accuracy and precision. Among such powdered products are various pharmaceuticals, e.g. sulphur drugs, powdered vitamins and the like, other dry powders or chemical materials such as sugar, salt, gun powder or other highly explosive powders, as for example, a lead Azide, Lead Styphanate, tracer powder mixes, pyrotechnic smoke mixes and the like. Powdered material as hereinafter used includes any aggregation of loose materials of solid particles including not only ground, but also crystalline material and flaky material. It is not necessary that the material be homogenous. The basic requirement is that the material be reasonably free to flow, and that the material be such that it can be packed in a metering or measuring chamber, and which charge of material can then be retained within its measuring chamber by maintaining a negative pressure or vacuum in the chamber.

50 A method embodying the invention may be automatically performed by a powder measuring and dispensing apparatus in which the metering or measuring chamber is included in a rotating turret head or formed in the nature

of a measuring and dispensing gun as will be hereinafter described.

One apparatus embodiment (Figs. 1 to 5 and 25) by which a method embodying the invention may be performed comprises a filling and dispensing machine 30 utilizing a turret filling head of the type disclosed in U.S. Patent No. 2,540,059, but modified in accordance with this invention. Such an apparatus comprises essentially a supporting frame 31 on which the respective component portions of the apparatus are supported. Suitably journaled on the frame 31 is a shaft 32 which has mounted thereon the rotary turret filling head 33 with one or more filling or measuring chambers 34. As illustrated in Figs. 1 and 2, the filling head turret 33 is illustrated with a plurality of similarly constructed measuring chambers 34. Universally mounted immediately above the filling head in a manner similar to that described in Patent No. 2,540,059 is a hopper 35 adapted to contain a supply of bulk powdered material 36. If desired, a suitable stirrer (not shown) may be provided in the hopper 36 to effect agitation of the powdered material to insure positive flow. As there is a tendency for the fine powders to escape between the discharge opening 37 of the hopper 35 and the turret filling head 33, the surface 38 of the filling head is preferably ground to a high polish and lapped with the contacting members of hopper 35 so that a very fine fit is obtained between the hopper and the periphery of the turret head. As described in Patent No. 2,540,059, the hopper 35 is mounted on a lever which in turn is journaled upon the frame 31 and held in position with a spring. The overall mounting of the hopper 35 is such that the hopper 35 is free to move small incremental amounts in any direction so that any eccentricities or deviations in the alignment of the filling head 33 are compensated so that the hopper seals powder-tight thereagainst. As shown in the drawings, a doctor blade 39 is disposed adjacent the edge of the hopper 35 in the direction of rotation so that the charge of powder filling the respective metering chambers 34 as the turret head 33 rotates is dressed down, evenly to the surface of the filling head turret. In this manner, any excess of powder material which tends to adhere to the end of the metering chamber 34 is returned to the bulk powder supply. By dressing the top surface, each individual charge of the respective chamber defines an identical volume and because of the peculiar and unexpectedly uniform density of the powder material, and quantity of each individual charge has been found to be remarkably consistent and uniform. With routine care, the charging of each of the respective chambers 34 can be easily kept within negligible error of the desired value.

As disclosed in Fig. 25 the respective metering or measuring chambers of the filling head

are defined by a sleeve 40 which is lapped to match the complementary bore 41 formed in the filling head 33 adapted to receive the same. Slidably mounted within the sleeve 40 is a piston means 42 comprising a piston head 43 and a connected piston rod 44. As shown, the piston rod 44 extends radially through the sleeve and toward the center of the turret head 33. The inner end portion of the piston rod 44 defines a cam follower 44A end which is adapted to ride on a stationary cam 45. Suitable spring means 46 are provided to bias the respective piston rods 44 against the contour of the stationary cam 45.

As best seen in Fig. 2, it will be noted that the stationary cam 45 is provided with a peripheral cam surface which is contoured to effect displacement of the piston head 43 relative to the sleeve 40 as the rotary turret head 33 is rotated in a counter-clockwise direction about the shaft 32.

The piston head 43 connected to the respective piston rods 44 in each of the respective measuring chambers 34 is formed of a porous material which is rendered pervious to a gaseous medium, but impervious to the powdered material. Thus piston head 43 may be formed of any desirably foraminous material that will enable the same to be rendered impervious to the powdered material but pervious to a gaseous medium, e.g. compressed air and the like. As shown in Fig. 25, a portion of the piston rod 44 is provided with a longitudinally extending bore 47 in communication with the porous piston head 43, and which bore 47 is provided with a lateral opening 48 that communicates with an annular chamber 49 disposed immediately behind the piston head 43 and circumscribing the piston rod 44. Chamber 49 is formed with orifice 49A. Accordingly, the opening 48 in the piston rod 44 communicates through orifice 49A of chamber 49 with an orifice 50. This orifice 50 in turn bears upon the surface of a valve block 51 which valve block acts as a support block for the filling head turret through bearing surface 52 and which supports the shaft 32 and filling head assembly 33 through bearing 53. The valve block 51 in the embodiment illustrated has cut therein an arcuate vacuum chest or groove 54 which can communicate with the orifice 50. The groove 54 in turn is suitably connected to a vacuum pump or other source of negative pressure, by passageway 55, so that a vacuum can act through the orifice 50 when communicating with the groove 54, and the foraminous piston head 43. The arrangement is such that a vacuum is maintained in the measuring chamber 34 to effect the charging thereof from the time the chamber is passed under the hopper 35 until it is nearly in the position of discharge.

As shown in Figs. 1 to 3, the measuring chamber 34 with the piston head 43 retracted to loading position in passing the hopper dis-

charge end and subjected to a negative pressure causes the material 36 in the discharge end of the hopper to be drawn or sucked into the measuring chamber 34. The material so drawn into the chamber 34 is maintained at an evacuated density proportional to the degree of negative pressure or vacuum in the chamber. As the measuring chamber 34, after charging, moves beyond the doctor blade 39, the end of the chamber 34 is dressed or wiped clean of any excess powder adhering thereto. Thus, as the rotating filling head 3 rotates, the measured charge contained in each of the respective filling chambers is rendered substantially uniform and accurate as the volume and density of the charged material is maintained constant through the successive filling operations.

As best seen in Fig. 4 there is disposed adjacent the filling head turret at a point beyond the passage of the measuring chamber from the hopper and in the direction of rotation of the filling head, an anvil or compacting means 56 which is disposed in contiguous relationship with the filling head turrets so that the anvil means defines a closure for the open end filling chamber 34 at a predetermined position beyond the hopper discharge end. It is to be noted that the stationary cam 45 is formed so that when a measuring chamber 34 is disposed opposite the anvil 56, the respective piston rods 44 riding the cam contour cause displacement of the piston head toward the anvil 56 a predetermined amount as to further compress the powdered charge between the anvil 56 and the displaced piston head 43. In this manner the density of the powdered charge is increased to a predetermined value due to the compression imparted thereto and forms the charges into a powder slug having a density which is greater than the evacuated density of the charge material as it emerged from the hopper and sufficient to enable the slug to be handled as a substantial solid mass. Upon further rotation of the turret head 33 in the direction of rotation, it is to be noted that the piston head 43 is further advanced due to the cam contour so that in the discharging position of the metering chamber 34 as seen in Fig. 5, the piston head advanced to its maximum or protracted position thereby forcing the compacted powder slug ahead of it out of the chamber. However, it will be noted that during most of this movement of the piston 42, the negative pressure acting on the slug or charge is still maintained so that the charge or compacted powder slug is adhered to the end of the advancing piston head.

At the discharge position of the measuring chamber, there is provided a passageway or tube 57 which connects to a source of positive fluid pressure (not shown), as for example, compressed air. Accordingly, as an orifice 50 of the filling head moves into or toward the discharge position, the orifice 50 lines up with

and is placed in communication with passage-way 57 which connects with the source of positive fluid pressure. Therefore, as indicated in Fig. 5, with the piston head advanced to its protracted position, the powdered slug which is otherwise retained thereon by the negative pressure acting on the piston head is positively separated therefrom by a pulse or jet of high-pressure fluid directed to the piston head as the chamber moves past the high pressure line 57. At the point of discharge suitable means is provided for positioning a container under the measuring chamber to receive the slug.

With the construction and method described, it is to be noted that the compacted powder slug is precisely positioned immediately above a container, adapted to receive the same, and further that it is positively ejected into such container with a minimum of dusting and/or contamination of the atmosphere and/or the machine. Also it is to be noted that by pre-compacting the measured charge of powder within the respective measuring chamber 34 prior to the discharge thereof, a given volumetric amount of powdered material at a given density can be reduced so that it may be accommodated in a container of a size which would not normally accommodate the given volumetric amount of powdered material in either its initial loose form or its evacuated density.

For ease of assembly and to avoid the necessary maintenance of tolerances during assembly, the shaft 32 about which the turret 33 rotates is mounted so that all end play is taken out by a spring means 58 which presses against a collar (not shown) pinned to the shaft 32 at one end, and pressing against the thrust bearing 59 at the other. Thus the spring assembly 58 holds the filling head turret tightly against the valve block 15, thus taking care of any wear and/or preventing loss of fluid pressure or vacuum.

It will be understood that a driving motor (not shown) is provided, which through necessary speed reducing can be operatively connected to the shaft to effect rotation thereof in timed sequence to a suitable container feeding apparatus for successively delivering a series of containers sequentially through the discharging position of the respective chambers.

In Fig. 6 there is illustrated a modified embodiment in which the compacting means 60 is illustrated as comprising an endless belt 61 and it is utilized in conjunction with a filling head turret 62 similar to that described with respect to Figs. 1 and 2. In this embodiment the compacting means 60 comprises an endless belt threaded about suitable sprockets or pulleys 63, 64, in which one flight 61A of the belt is disposed contiguous to or follows a portion of a circumferential portion of the circumference of the filling head turret 62. The belt may be disposed in either friction driving rela-

tionship with the periphery of the filling head turret 62 so that rotation of the filling head turret effects the drive of the endless belt 60 or the sprocket 63 or 64 about which the belt is threaded may be connected with synchronous driving relationship with the turret head 62. As previously described, it is to be noted that as the respective measuring chamber 65 approach the flight 61A disposed contiguous to the circumference of the filling head turret 63, the stationary cam 66 effects the displacement of the piston head 67 toward the belt 60 thereby causing the powdered charged material confined between the belt 60 and the piston 67 to be compressed a predetermined amount to define the necessary compacted slug powder. As the filling head turret 62 rotates beyond the endless belt 60 the stationary cam 66 effects progressive movement of the piston head 67 toward its protracted position, whereupon the compacted slug of powdered material is ejected in the manner hereinbefore described with respect to Figs. 1 and 2.

Where the method and apparatus herein described is to be utilized for handling explosive or propellant type powders, the compacting means 56 or 60 are preferably formed of a resilient, conducting material such as conductive rubber, conductive neoprene and the like. This is to minimize any danger of sparking or creation of an electric charge which may cause such explosive powders to ignite or detonate.

Fig. 7 illustrates an arrangement wherein a plurality of filling head turrets 70 of the type described with respect to Figs. 1 and 2 may be suitably journaled about the shaft to define a gang turret head. By so ganging a plurality of turret heads 70 as herein described it will be apparent that production of a given apparatus can be increased accordingly.

The measuring and dispensing of equal predetermined amounts of powder can also be satisfactorily attained by utilizing a gun-type measuring device. Figs. 8 to 12 illustrate schematically how such a method can be practiced with a filling and dispensing gun type apparatus. The metering and dispensing gun 70 comprises essentially of an elongated tubular member or barrel 71 in which a piston means 72 is movably mounted for movement between a retracted loading position and a protracted discharging position. The piston means 72 comprises a piston head 73 formed of a porous material which is pervious to a gaseous medium, but impervious to the powdered material adapted to be handled thereby. As schematically illustrated in Figs. 8 to 12 the piston rod 73A connected to the piston head 73 extends upwardly through the end 75 of the barrel 71. Accordingly, the barrel member to the rear of the piston head defines a chamber 76 which is alternately connected with a vacuum pump 77 or other suitable device capable of drawing a vacuum on the chamber 76 and



a source of high pressure gas, e.g. an air compressor 78. As seen in Figs. 8 to 12, the tubular barrel member 71 is provided with an opening 79 which connects with a flexible tube or other suitable conduit 80. The conduit 80 is operatively connected to a valving means 81 for alternately connecting to the chamber 76 a source of negative pressure 77 or to a source of pressure gas 78, as will be hereinafter described.

In operation, it will be noted that with the piston head 73 retracted to its loading position, as seen in Fig. 8, the open end of the barrel defines the measuring chamber 82 which is disposed into a supply 84 of bulk powdered material which is desired to be measured and dispensed. In this position, the valve member 83 of the valve means is set so as to connected the source of negative pressure 77 to the conduit 80 connected to the tubular barrel member 71 to draw a vacuum thereon. Because the piston head 73 is pervious to a gas, the vacuum or negative pressure acting thereon causes the powdered material in the supply 84 to be drawn into the measuring chamber 82. The charged gun is then withdrawn from the source of bulk powder supply and passed over a doctoring means to dress the end of the gun 71 as seen in Fig. 9. The doctoring means may comprise the edge of the bulk supply or the like. By doctoring the open end of the metering gun charged with a powdered material over a doctoring edge, the level of the charge is dressed so that equal predetermined amounts of powdered material corresponding to the volumetric capacity of the measuring chamber 82 are assured on each filling operation. The gun so charged and dressed is then moved to a smooth compacting surface 85 which may be formed of any suitable material. However, in the handling of high-explosive materials and gun powder it is desired that the compacting surface 80 be formed of a hard, conducting material, as for example, conductive rubber, thereby obviating the possibility of sparking and/or creating static electricity which could ignite the explosive powder contained within the metering chamber 82. With the end of the metering chamber disposed contiguous to the compacting surface 85 and still maintaining a negative pressure on the porous piston head 73, the piston head 73 is advanced toward the open end of the measuring chamber 82 so as to compact the material charged therein between the piston head 73 and the compacting surface 85. (See Fig. 10.) Upon such compaction, the powdered material or charge within the metering chamber 82 is formed into a compacted slug of predetermined density, which density is greater than the initial evacuated density of the powder in the chamber 82. The gun 70 is then moved to a position wherein it is desired to eject the compacted powder slug therefrom, as for example over the open end of a container 86. To effect ejection of

the compacted powder slug from the measuring chamber 82, the piston head 73 is advanced to a protracted position thereof as noted in Fig. 11. To effect positive separation of the slug from the piston head 73, a jet of a high-pressure gaseous medium, as for example, compressed air, is directed to the barrel portion 71 of the gun. This is attained by shifting the valve 83 to connect the high-pressure source 78 to the chamber 76. See Fig. 12. Since the piston head 73 is rendered pervious to such gaseous medium, the pressure of the medium flowing through the porous piston head will blow the powder slug from the end of the piston head 73 to effect positive separation. Such pulse of gaseous medium will further purge the piston head of any powder particles.

Figs. 13 to 24 are directed to an apparatus 90 for effecting automatic operation of a measuring and dispensing gun 91 operating with the principle described with respect to Figs. 8 to 12.

As best seen in Figs. 13 and 14, the apparatus 90 for effecting automatic operation of the measuring and dispensing guns 91 comprises a frame 92 on which a gun mount 93 is mounted for movement from a neutral or start position S.P. to a filling station F.P. through a doctoring position D.P. to a compacting position, C.P., to a discharging or ejection position E.P. and back to neutral or starting position S.P.

Referring to Fig. 24, the gun mount 93 comprises a pair of relatively movable cross bars 94, 95 which are slidably supported for limited vertical movement on a pair of upright post or stanchion members 96—96. The stanchions or upright posts 96 in turn are connected to the end of sliders 97 which are mounted for relatively horizontal movement over to table top 98 of the machine frame. Each of the respective sliders 97 is slidably mounted in suitable bearing means 99 fixed to the frame 92. Connected to the top of the respective stanchions 96 and extending therebetween is a tie bar 100. A pair of angled brackets 101 connect the tie bar 100 to a push member 102 which extends between and connects to the respective sliders 97 for further bracing the upright stanchions 96.

A drive means 103 is operatively connected to the push member 102 to effect reciprocal movement of the associated sliders 97 and connected gun mount 93 between the respective positions or stations, S.P., F.P., D.P., C.P., E.P., and S.P. In the illustrated embodiment the drive means 103 comprises a cam shaft 104 rotatably journaled on the machine frame 92. Mounted on the cam shaft 104 is a contoured cam 105 for controlling the movement of an operating linkage 106, 107 operatively connected between the cam 105 of the cam shaft 104 and the push member 102 of the sliders 97. Accordingly, the cam 105 is con-

toured to effect horizontal displacement of the sliders 97 and gun mount 93 carried thereby in sequentially phased relationship to the other machine operations to be herein described.

5 Referring to the gun mount 93 shown in Fig. 24, it comprises an upper cross bar 94 slidably mounted with respect to the opposed support stanchions 96. In the illustrated embodiment the upper cross bar 94 is provided with opposed bearing collars 94A by which the bar 94 is slidably mounted on the stanchions 96. The lower cross bar 95 is similarly provided with bearing collars 95A for slidably connecting to the same the opposed stanchions 96. 10 The lower cross bar 95 is also dependently supported from the upper cross bar 94 by a pair of spaced studs 108. The studs 108 extend freely through slightly oversized bores 108A formed in the lower cross bar 95, with the upper end of the studs 108 threadly engaged in a tapped hole 109 in the upper cross bar 94. As shown, a coil spring 110 is disposed about the respective studs 108 to exert oppositely directed forces on the bars 94, 95 for normally maintaining the bars 94, 95 in spaced relationship. However, the arrangement is such that the respective cross bars 94, 95 are rendered relatively movable with respect to one another as will be hereinafter described. If desired, adjustable means are provided for varying or adjusting the spacing between the cross bars 94, 95. The adjusting means as shown comprises nuts 108B threaded on the studs 108. Thus it will be noted that the spacing between cross bars 94, 95 can be varied depending on the particular setting of the adjusting nuts 108B. As will hereinafter become apparent, this adjustment is utilized to control the volumetric amount of powdered material to be dispensed by the respective gun 91 carried on the gun mount. The gun mount 93 is also provided with stop means to limit relative movement between the respective cross bars 94, 95. As shown, the upper bar 94 is provided with spaced threaded stops 113 which engage bearing 114 to limit downward movement of the upper cross bar 94 relative to the lower cross bar 95 when the mount 93 is moved to the compacting station C.P. as will be described. The uppermost position of the cross bar 94 may be adjusted by means of a pair of screw studs 111 threaded through tapped bores 111A extending through the tie bar 100, the end of such studs bearing on pads 112. 55

Connected to the gun mount 93 and carried thereon are a plurality of metering and dispensing guns 91 for picking up and dispensing measured charges of powdered material. In the illustrated embodiment a gang of eight guns 91 are carried on the gun mount 93, each of the guns 91 being similar or alike in construction. 60

Each gun 91 comprises an outer tubular barrel 114 which is suitably connected to a barrel 65

bracket 115 connected to the lower cross bar 95. Slidably disposed within each barrel member 114 is a piston means comprising a piston rod 16 and a connected piston head 117. The piston head 117 is slidably disposed within the outer barrel member 114; and the connected piston rod 116 is suitably connected to a bracket 118 fixed to and carried by the upper bar 94 of the gun mount 93. Referring more particularly to Figs. 19 to 22, the piston head 117 is formed of a porous material which is pervious to a gaseous medium, but impervious to the powdered material. The piston rod 116 in turn comprises a tubular member having a diameter smaller than the internal bore of the barrel 114. The bore 119 of the gun is operatively connected via a valve means to a source of negative pressure and a source of gas under pressure by a suitable flexible conduit (not shown). Accordingly the end portion of the barrel between the piston head 117 and the outer end 120 defines a measuring chamber 121 of a predetermined volumetric measure. By effecting relative adjustment of the gun mount bar 95 by turning adjusting nuts 108B, the piston rod 116 and connected head 117 carried by the bracket 118 connected to upper bar 94 are shifted accordingly within the barrel 114 to vary the size of the measuring chamber 121. It will thus be noted that for any given size of the measuring chamber 121 the distance between the barrel bracket 115 and piston bracket 118 will be a given distance, e.g. a distance X. 70 75 80 85 90 95

An operating means 122 is operatively connected to the gun mount 93 to effect vertical movement thereof along the respective upright stanchions 96. In the illustrated embodiment the upper bar 94 is provided with opposed trunions 123 which are respectively received in the bifurcated end portion 124A of an operating lever 124. The operating lever 124 in turn is fulcrumed about a suitable pivot 126 carried on brace 101. The other end of the lever 124 is connected by a suitable ball joint 127 to a connecting link 128, the latter having its other end connected to the end of a cam follower 129 which rides on a suitable contour cam connected to the cam shaft 104. The respective cams for operating the gun mount 93 horizontally and the cam for effecting vertical movement of the gun mount 93 and guns 91 carried thereby are timed to operate in a prescribed manner as will be hereinafter described. 100 105 110 115 120

In the loading or filling station F.P. of the machine there is disposed a row of receptacles 130, each defining a powder supply for each of the respective guns 91 carried by the gun mount 93. Each supply receptacle 130 includes a recess 131 for containing a supply of powder 132 material. Extending over the open end of the receptacle 130 is a flexible diaphragm 133 which forms a cover therefor. If desired, the diaphragm 133 may extend over 125 130



only a portion of the supply recess 131. In this manner the recess 131 of each receptacle may be replenished with powder material through the uncovered portion 134. Each diaphragm 133 is provided with an aperture 135 therein, the aperture 135 being smaller than the outside diameter of the measuring gun barrel 114. A vibrating means 130A is operatively connected to the supply.

Connected to one end of the aligned powder supply receptacle 130 is an upwardly extending doctoring blade 136, preferably formed of a resilient material, e.g. rubber.

Immediately ahead of the doctoring blade 136 there is provided the compacting station C.P. Essentially the compacting station C.P. comprises a surface 137 against which the ends of the respective gun barrels 114 are brought to bear after passing the doctor blade 136 that dresses the powder charge carried by each gun 91 during operation. In the event the apparatus 90 is set up to handle explosive types of powders and propellants, the compacting surface 137 is preferably formed of a resilient, conducting material, e.g. conductive rubber, conductive neoprene or the like. This is to reduce any tendency of sparking or friction which may cause ignition of such explosive powders. As will be described, the operation of the measuring gun 91 is such that the piston head 117 is displaced toward the compacting surface 137 a predetermined amount to precompact the powdered charge within the measuring chamber 121 of the gun 91. Such compaction forms a powder slug which can be handled as a solid.

Operatively associated with the meter gun apparatus 90 and disposed to one side of the machine is a container feeding mechanism 138 for arranging the containers, adapted to receive the powder charge, in a line and for advancing a series of such aligned containers to the powder filling apparatus 90. It will be noted that the container feeding apparatus is also operatively connected to the cam shaft 104 of the powder filling apparatus through an appropriate linkage drive.

Positioned on the bed or top 98 of the filling apparatus 90 is a locating bar 139 for receiving and properly positioning the containers at the filling station F.P. In the illustrated embodiment the container in fact comprises a capsule 140 supported on a puck or carrier 141, the latter functioning as a means for properly transporting the container or capsule 140 to the discharging station E.P. of the filling machine during operation.

A push bar 142 is operatively disposed on the top of the machine to advance the aligned container 140 from the initial aligned position I.P. (Fig. 14) thereof to the filling position F.P. of the machine. As seen in Fig. 14 the push bar 142 comprises an inverted channel portion 142A which is disposed in alignment with the feed channel 143 of the container

feeding machine. The push bar 142 is operatively connected to a push link 144. The other end of the push link 144 is connected to a cam follower 145 which rides an appropriate cam journaled on the cam shaft 104. As shown, the web 146 of the push bar channel 142 is provided with an opening 147 through which the metering or measuring gun 91 is inserted in the final dispensing position E.P. thereof.

The operation of the filling machine described is as follows. The container feeding apparatus 138 maintains a supply of containers and carriers 140, 141 in alignment and ready to be transported to the containing receiving station I.P. of the filling apparatus 90 as indicated in Fig. 14 wherein a series of eight carriers are disposed between the flanges of the push bar 142. From the container receiving station I.P. the push bar cam is contoured so that through the interconnecting linkage 144, 145 the push bar 142, in timed or phased relationship to the other movement of the machine, pushes the carriers and the containers 140, 141 supported thereon to the dispensing station E.P. as indicated in Fig. 14. In doing so the carriers 141 are moved against the locating bar 139 and are retained in position thereby until the containers or capsules 140 thereon have each been charged with a predetermined amount of powdered material from a respective gun 91.

As the carriers and containers 140, 141 are being so positioned the gun mount 93 is being horizontally transported to the portion wherein the respective guns 91 are disposed over the respective powder supply receptacles 130. This movement is effected by the cam and associated drive linkage 106, 107 for effecting horizontal movement of the slider 97.

When the guns 91 are disposed over the powder supply 130 the gun mount 93 is lowered so that the end of each gun barrel 114 extends through the aperture 135 in the diaphragm 133 covering the associated powder supply 130. At this time the chamber 150 back of the piston head 117 is subjected to a negative pressure. As a result the powder from the bulk supply 130 is sucked up into the measuring chamber 121. In this filling portion of the cycle, it is to be noted that the barrel 114 is moved into the powder supply 130 in a manner to prohibit the end of the barrel 114 from striking the bottom of the powder supply 130. See Fig. 19. Also it is to be noted that the distance between the piston rod mount 118 and barrel bracket 115 is maintained at a distance X. Also it will be noted that the barrel 114 in passing through the aperture 135 in the diaphragm 133 causes the encircling portion of the diaphragm to be displaced inwardly of the powder supply.

Upon charging of the respective measuring chambers 121, the gun mount 93 is retracted upwardly under the action of its drive means.

In doing so the encircling portions of the diaphragm 133 are reversed. See Figs. 16 and 17. As the barrel 114 is further retracted, the diaphragm 135 functions as a doctor means to dress any excess powdered material from the end of the measuring chamber 121 as the barrel assumes its normal position, the negative pressure being still maintained in the measuring chamber 121 to insure a uniform evacuated density of the powder charge therein and to maintain the charge within the chamber 121. In returning the charged guns toward the dispensing or discharging station E.P. the ends of the guns pass over a further doctor 136 to further dress the powder charge in the respective gun chambers 121.

With the guns 91 disposed over the compacting station C.P. the gun mount is again lowered under the influence of its operating cam drive mechanism to a point where the end of the charge barrel 114 engages the compacting surface 137. In this portion of the cycle the upper bar 94 carrying the respective piston rods 116 continues to its downward movement after the movement of the lower barrel bar 95 has stopped. In so doing the piston head 117 is displaced toward the compacting surface 137 to further compact the measured powdered charge as indicated in Fig. 21. At this point it will be noted that the distance between the barrel bracket 115 and piston bracket 118 is less than X.

After compaction, the gun mount 93 is returned to the discharging station where it is again lowered to a point immediately adjacent the open end of the container or capsule 140. In doing so the piston rod 116 and connected piston head 117 are actuated for movement relative to the barrel 114 for pushing the compacted slug outwardly of the barrel; the negative pressure still being maintained on the slug of powder.

As the powder slug is being received within the container 140 a pulse of high pressure gas is directed to the end of the porous piston head 117 to positively blow and separate the powder slug from the end of the piston.

The gun mount is then raised to its initial start position S.P. and the loaded capsules 140 and the carrier 141 supporting the same are returned to their initial container receiving position I.P. At this point the cycle is repeated, the newly arriving carriers forcing the filled capsules and their carriers 141 through discharge of the machine 90.

Figs. 26 to 30 illustrate various modifications and improvements in means for further minimizing the doctoring error in rotary turret head filling machines of the types illustrated in Figs. 1 to 7.

Referring to Fig. 26, the doctoring error of the rotary filling head can be further reduced. This is attained by forming the measuring chambers 160 of the filling head turret 161 with a tapering end portion 162 as shown in

Fig. 26. By so tapering the end 162 of the respective chambers 160 inwardly, the cross-sectional area of the open end of the chamber is reduced to a minimum. Accordingly, the amount of excess material which can adhere to the end of the measured charge is reduced to a minimum. In all other respects the operation of the filling head turret 161 is similar to that disclosed and described with respect to Figs. 1 to 7.

In the embodiment of Fig. 27, a brush means 165 is disposed adjacent the discharge end of the hopper 166, and the bristles 166 of the brush means function to doctor or dress the end of the measuring chamber.

In Fig. 28, the dressing of the measuring chamber 160 as the turret head 161 rotates through the hopper is attained by a jet 170 of gaseous fluid, e.g. compressed air or inert gas or the like. As shown, the jet 170 of fluid functions as an air knife to prohibit any excess powdered material from adhering to the measured charge. In this manner the accuracy of the measured charge can be maintained.

In Fig. 29, the dressing of the measured charge in chamber 160 is attained by a flexible wiper blade 171 engaging the periphery of the turret head 161.

In Fig. 30 dressing of the measured charge in the measuring chamber 160 of the turret head is attained by providing a slight spacing 181 between the end of the hopper 166 from which the turret head 161 emerges and the periphery of the turret 161. The spacing 181 is such so as to encourage a thin film of powdered material to form on the periphery of the turret head 161. As explained, the powder in the measuring chamber 160 is drawn into and maintained within the measuring chamber 160 by a negative pressure of predetermined force. The dressing in this form is thereby attained by disposing a nozzle 182 downstream from and adjacent to the spacing 181 defined between the hopper 166 and the turret head 161 and connecting the nozzle 182 to a source 183 of negative pressure having a force which is less than that which acts on the measuring chamber 160. Thus, as the turret 161 rotates past nozzle 182 the vacuum created thereby tends to draw therein any loose powder extending beyond the periphery of the turret head and the measured charge carried thereby.

Figs. 31 and 32 illustrate another apparatus for attaining a measured amount of powder at uniform density. In this form of the invention the powder supply 200 comprises a receptacle 201 which is connected on the end of spindle 202 rotatably journaled in suitable bearing 203. A motor means or other drive means not shown is connected to the spindle 202 to impart rotation to the supply receptacle 201.

A doctor-compressor blade 204 is suitably fixed and it is arranged to extend into the bowl of the receptacle. If desired, the inclina-

tion of the blade can be adjusted. In operation, the arrangement is such that the rotation of the bowl 201 relative to the doctor-compressor blade 204 is such that an area of the powdered material 205 as it passed under the blade is maintained smooth, and by applying a predetermined pressure on the blade 204 the powdered material passing thereunder is also compacted to a given density. Accordingly the powder in the supply bowl 201 emerging from under the doctor blade 204 is both smooth and compacted to a desired density, depending on the applied pressure of the blade.

To dispense the powder from the compacted area 206 of the powder in bowl 201, a metering chamber in the form of a gun 207 is inserted into the smooth and compacted zone 206 of the powder supply. In this form of the invention the gun comprises an outer tubular barrel 207A and a movable piston 207B. The head 208 of the piston is formed of a porous material as hereinbefore described.

An alternate means for smoothing and compacting the powder supply in the bowl or supply is to impart a vibrating motion thereto.

To eject the powder picked up by gun 207, the piston is advanced to push the measured slug outwardly of the chamber 209. Also the slug may be removed by subjecting the slug to a stream of high pressure fluid as hereinbefore described. Alternately the measured powder can be ejected from the measuring chamber 209 both by advancing the piston head to a protracted position and by admitting a pulse of high pressure air to the protracted piston head as described.

Fig. 33 shows the application of the tapered measuring chamber to a metering gun comprising a barrel 210 and piston 211. As described previously the piston head 212 is formed of a porous material. In this construction the end of the barrel or the portion defining the one end of the chamber 213 is tapered inwardly to reduce the exposed cross-sectional area of the chamber of a given volume to a minimum. In this manner the doctoring error can be reduced.

It will be understood that with respect to the various embodiments herein described, ejection of the slug from the measuring chamber, e.g. with respect to Figs. 8 to 12, can be attained by moving the barrel of the gun relative to a fixed piston, or by effecting movement of both the barrel and the piston relative to one another.

#### WHAT WE CLAIM IS:—

1. An apparatus for measuring and dispensing predetermined amounts of powdered material, comprising a measuring chamber having an open end, a piston including a piston head disposed within the chamber, said piston head being pervious to a gaseous medium and impervious to the powdered material, vacuum means to subject the measuring chamber to a negative pressure through the piston head

during charging of a predetermined measured amount of powdered material into the chamber, means to effect relative movement between the chamber and the piston head to eject the powdered material charged into the chamber, and means for compacting the powdered material before or after charging of the measuring chamber to provide a slug within the measuring chamber.

2. Apparatus according to claim 1, wherein the compacting means includes an anvil against which the chamber is moved so that the charge of powdered material is compacted between the anvil and the piston head as the piston head advances from a retracted loading position to a protracted discharging position.

3. Apparatus according to claim 2, wherein the anvil is formed of a resilient conductive material.

4. Apparatus according to claim 1, including a source of positive gas pressure and a conduit for directing the positive gas pressure to the piston head in the ejecting position thereof to blow the slug free of the piston head.

5. Apparatus according to claim 1, wherein the measuring chamber converges towards the open end thereof whereby to minimise the amount of excess powdered material adhering to the open end of the chamber during a charging operation.

6. Apparatus according to claim 1, wherein the compacting means includes a rotatable supply of powdered material and a doctor-compressor blade operating on the powdered material in the supply for compacting an area of the powdered material as it moves past the blade.

7. Apparatus according to claim 1, wherein the measuring chamber is disposed in a rotary turret arranged for rotation between a loading position and a discharging position.

8. Apparatus according to claim 7, wherein the compacting means includes an anvil disposed adjacent to the turret at a position intermediate the loading and the discharging positions.

9. Apparatus according to claim 7, wherein the compacting means includes an endless surface disposed adjacent a circumferential portion of the turret intermediate the loading and discharging positions.

10. Apparatus according to any one of claims 7 to 9, including a doctor for doctoring any excess powdered material from the chamber as the chamber is moved past a supply of the powdered material.

11. Apparatus according to claim 1, wherein the measuring chamber is provided in an extended tubular barrel.

12. Apparatus according to claim 11, including a powder supply in the form of an open-top receptacle adapted to contain the powdered material, a flexible diaphragm extending across the top of the receptacle, such diaphragm having formed therein an aperture



which is substantially smaller than the tubular barrel adapted to be inserted therethrough to remove a quantity of the powdered material, so that a portion of the diaphragm engaging the barrel is deflected inwardly of the receptacle upon insertion of the barrel therein, and whereby upon removal of the barrel the diaphragm portion is reversely deformed and wipes excess material from the end of the measuring chamber as the barrel is removed.

13. Apparatus for filling containers with predetermined amounts of powdered material, comprising a powder supply, a measuring chamber with an open end provided in a tubular barrel having a piston movably mounted therein, the piston including a porous piston head pervious to a gaseous medium and impervious to the powdered material, piston activating means for effecting movement of the piston in the barrel, means for inserting the barrel into the powder supply with the piston head in a retracted loading position, vacuum means for subjecting the measuring chamber to a negative pressure through the piston head for charging the chamber with a predetermined amount of the powdered material, means for moving the barrel from the powder supply to a container to be filled, an anvil disposed between the powder supply and the container and against which the powdered material in the measuring chamber is compacted by movement of the piston head, when the barrel is abutting said anvil, to an intermediate compacting position to form a slug having a density greater than the evacuated density of the powdered material, the piston activating means being operable to move the piston head to a protracted discharging position on the barrel reaching the container to eject the slug from the measuring chamber, and means for separating the slug from the piston head in the protracted discharging position.

14. Apparatus according to claim 13, including a doctor for doctoring excess powdered material from the barrel as it is withdrawn from the powder supply.

15. Apparatus according to claim 13 or 14, wherein the separating means comprises a source of positive fluid pressure directed to the measuring chamber when the piston head is in the protracted discharging position.

16. A method of measuring and dispensing

a predetermined amount of powdered material, comprising the steps of: positioning an open end of a measuring chamber provided with a movable piston member adjacent to a supply of powdered material, charging the chamber with a predetermined measured amount of powdered material by subjecting the chamber to a negative pressure through a piston head of the piston member which is impervious to the powdered material and pervious to a gaseous medium, the powdered material being retained in the chamber by maintaining the negative pressure in the chamber, positioning the charged chamber in abutment with an anvil, effecting displacement of the piston head to compact the powdered material within the chamber between the anvil and the displaced piston to form a slug, and discharging the compacted slug of powdered material from the chamber by further displacement of the piston at a point removed from the anvil.

17. A method according to claim 16, including the step of effecting separation of the slug from the piston head in the discharging position thereof by changing the negative pressure operating on the slug to a positive pressure whereby the latter effects separation by blowing the slug free of the piston head.

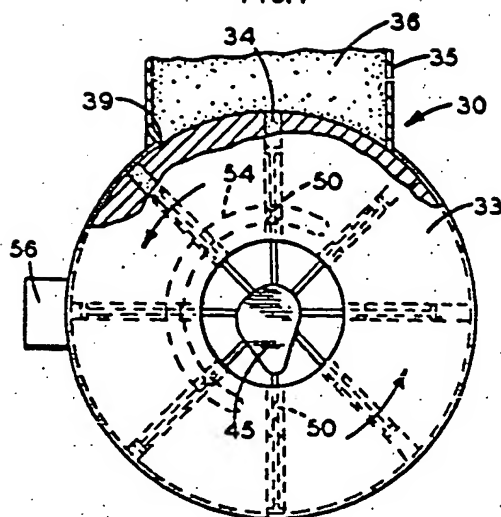
18. A method according to claim 16 or 17, including the step of doctoring excess powder extending beyond the opening of the chamber prior to positioning the charged chamber adjacent the anvil.

19. Apparatus for measuring and dispensing equal predetermined amounts of powdered material substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

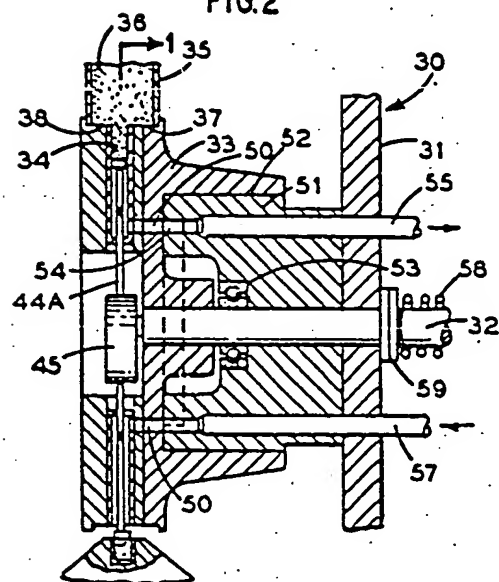
20. Methods of measuring and dispensing a predetermined amount of powdered material substantially as hereinbefore described with reference to the accompanying drawings.

FORRESTER, KETLEY & CO.,  
Chartered Patent Agents,  
Jessel Chambers,  
88/90 Chancery Lane,  
London WC2A 1HB.  
and  
Rutland House,  
Edmund Street,  
Birmingham 3.  
Agents for the Applicants.

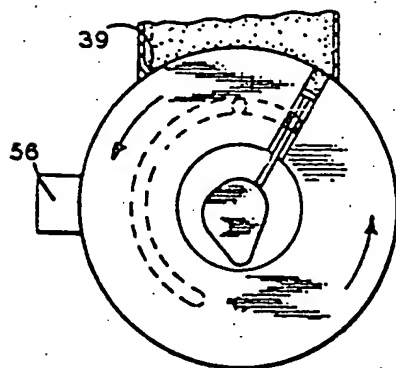
FIG. 1



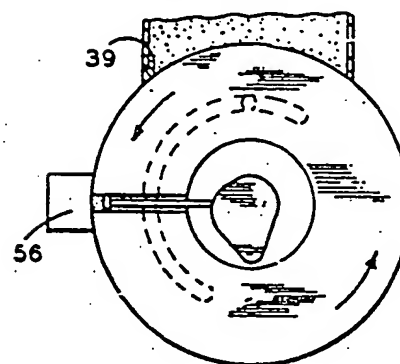
**FIG.2**



**FIG.3**



**FIG.4**



**FIG. 5**

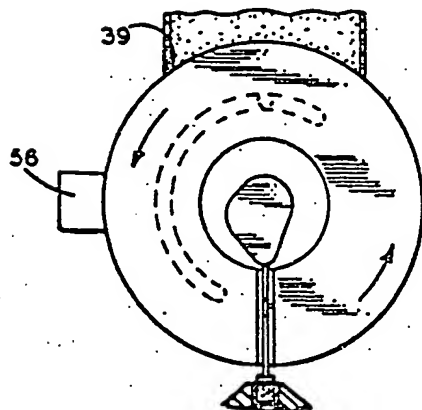


FIG. 25

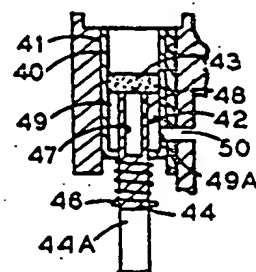


FIG.31

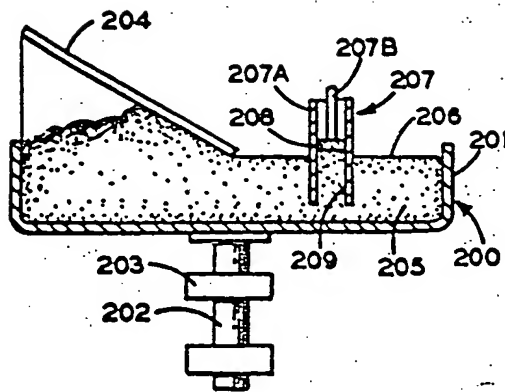


FIG.32

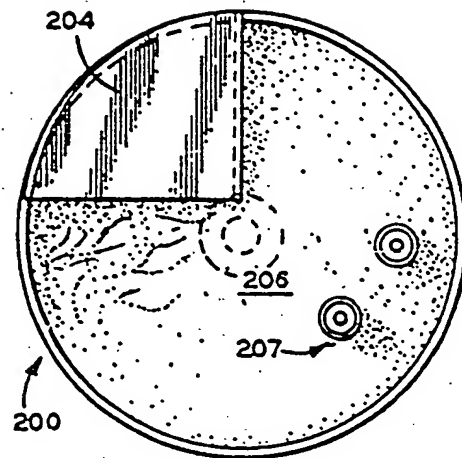


FIG.6

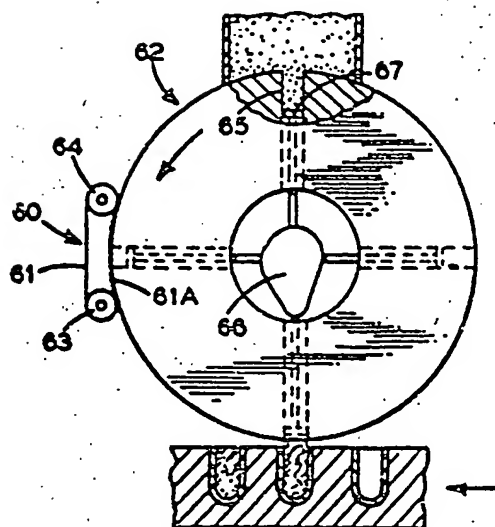
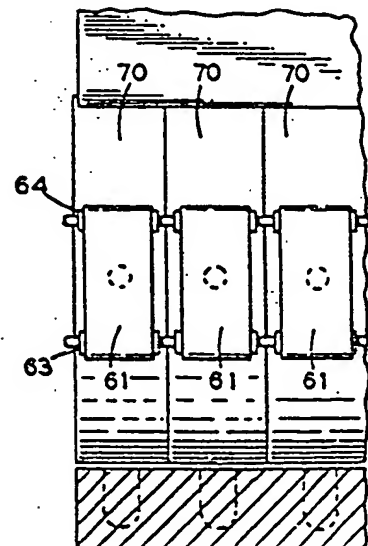


FIG.7





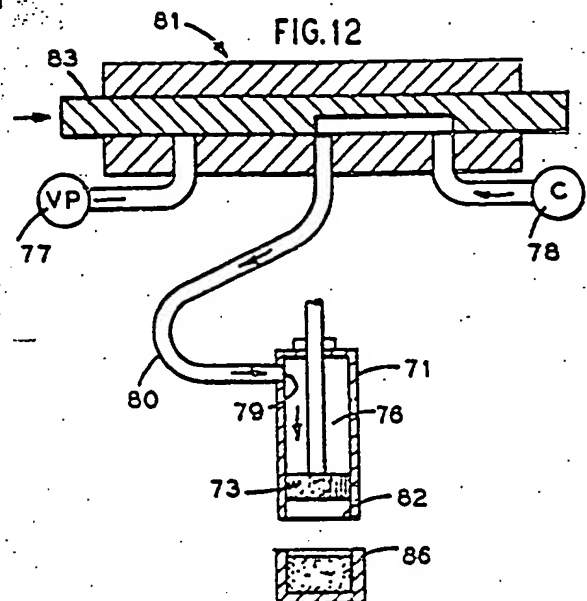
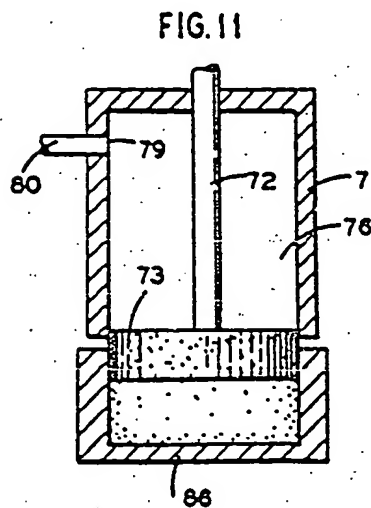
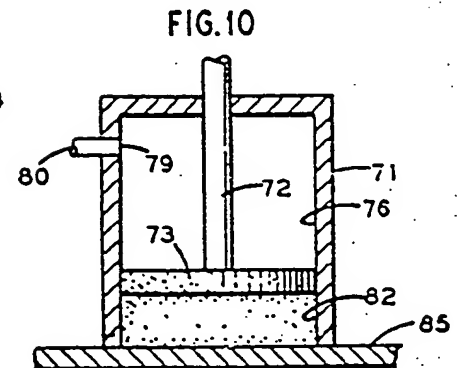
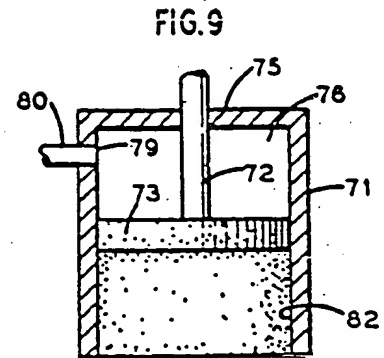
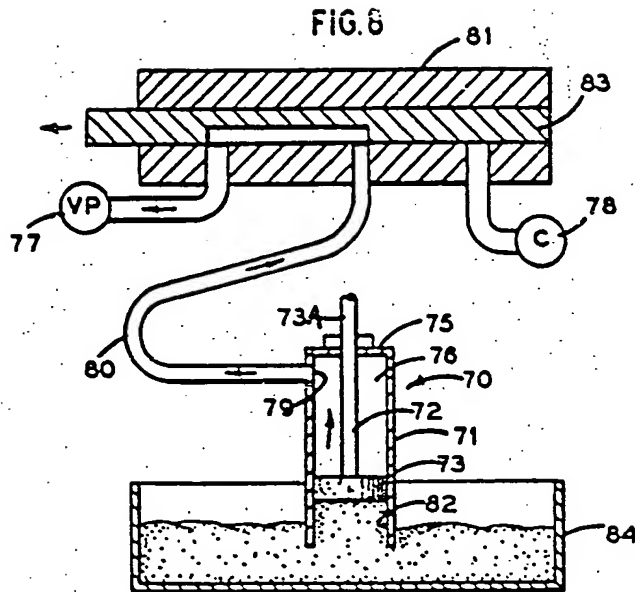
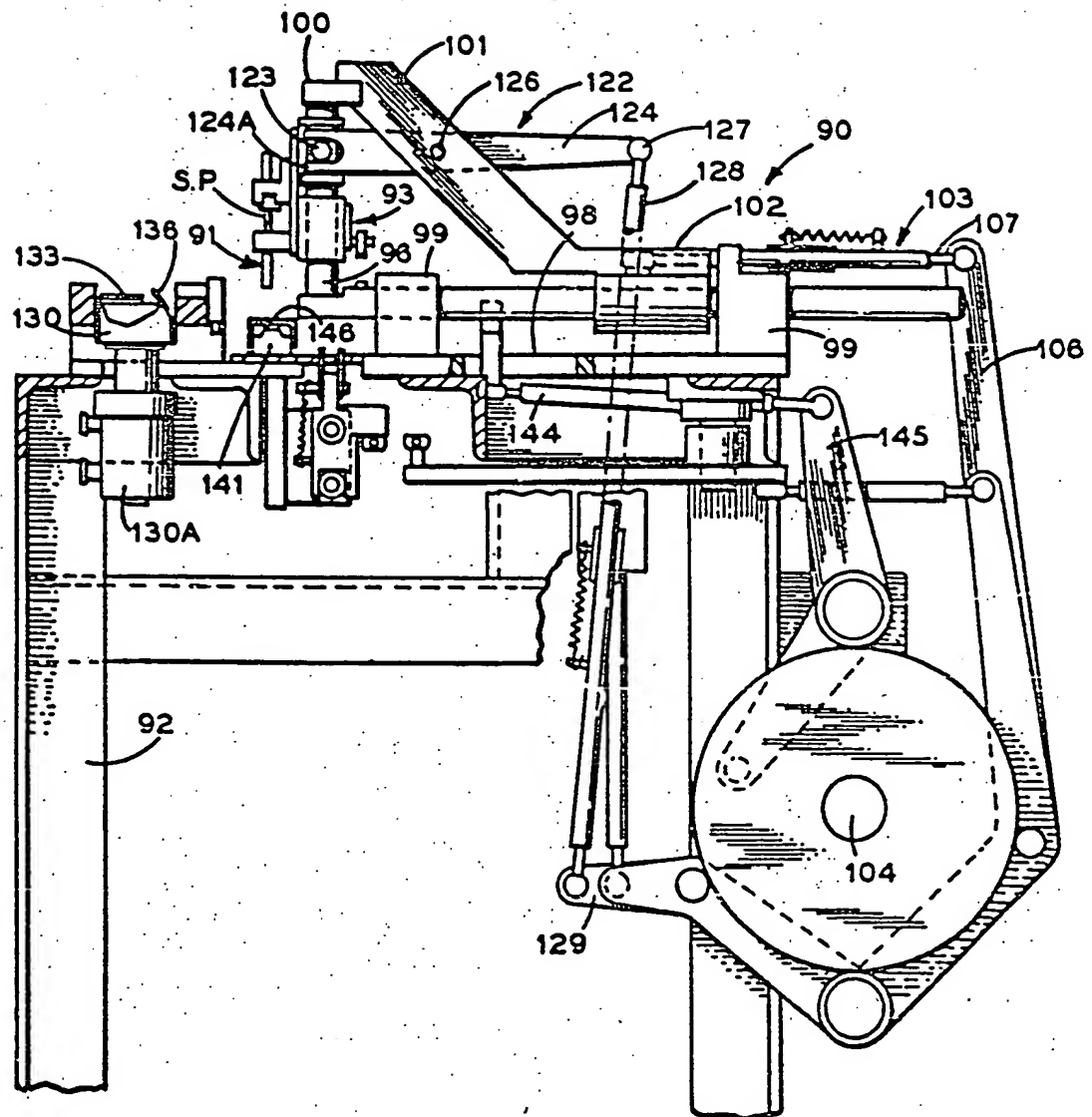


FIG. 13



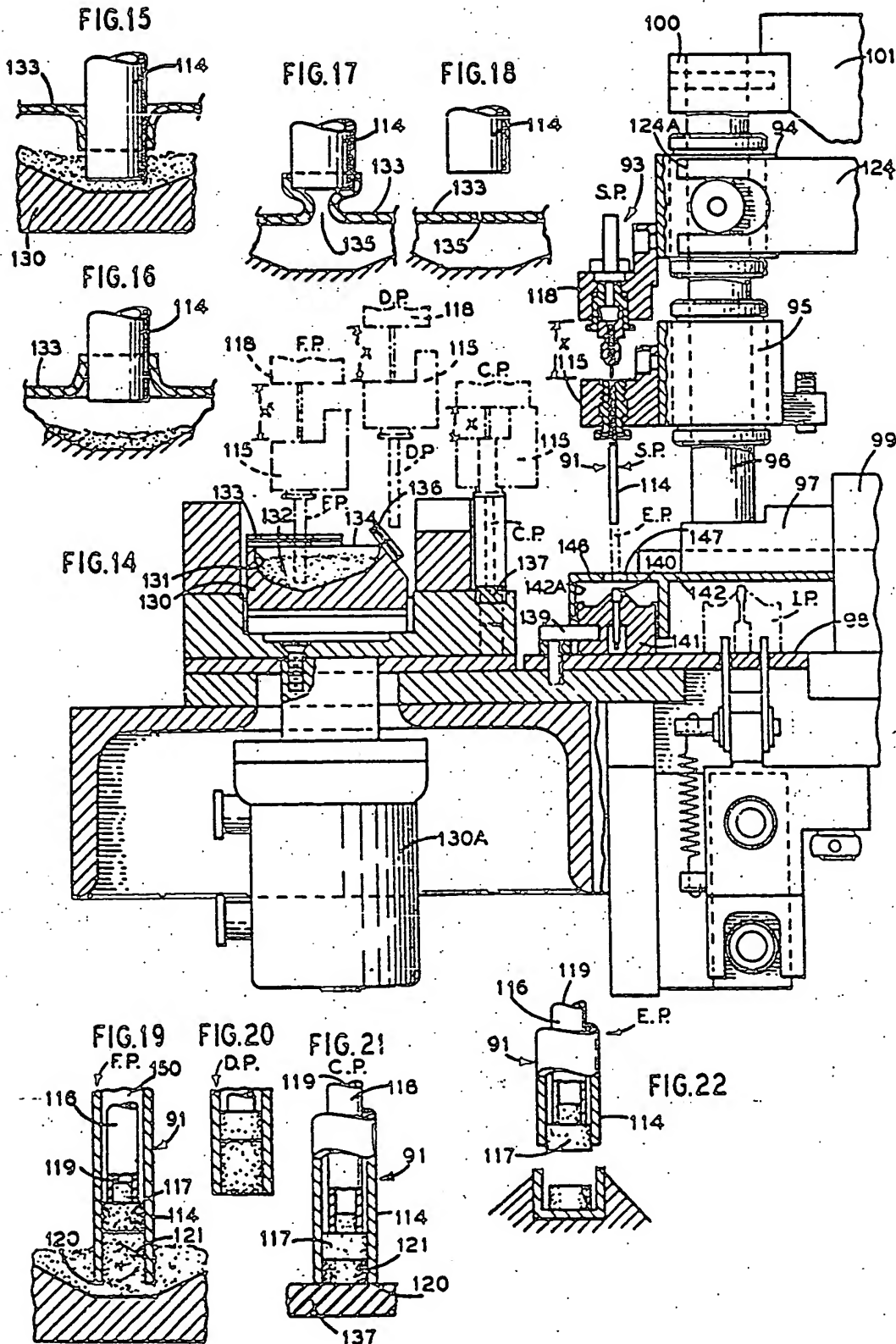




FIG.23

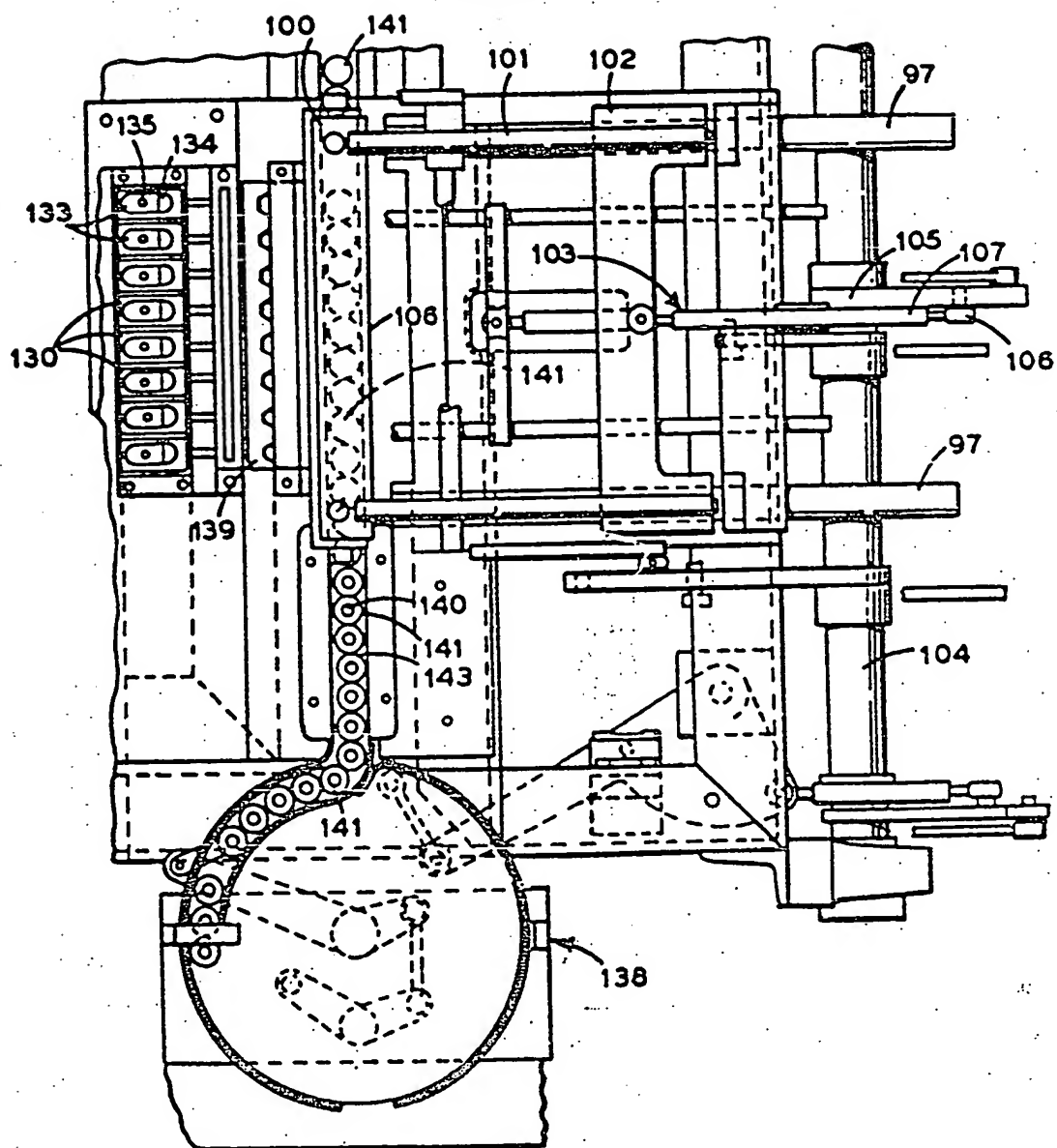


FIG. 24

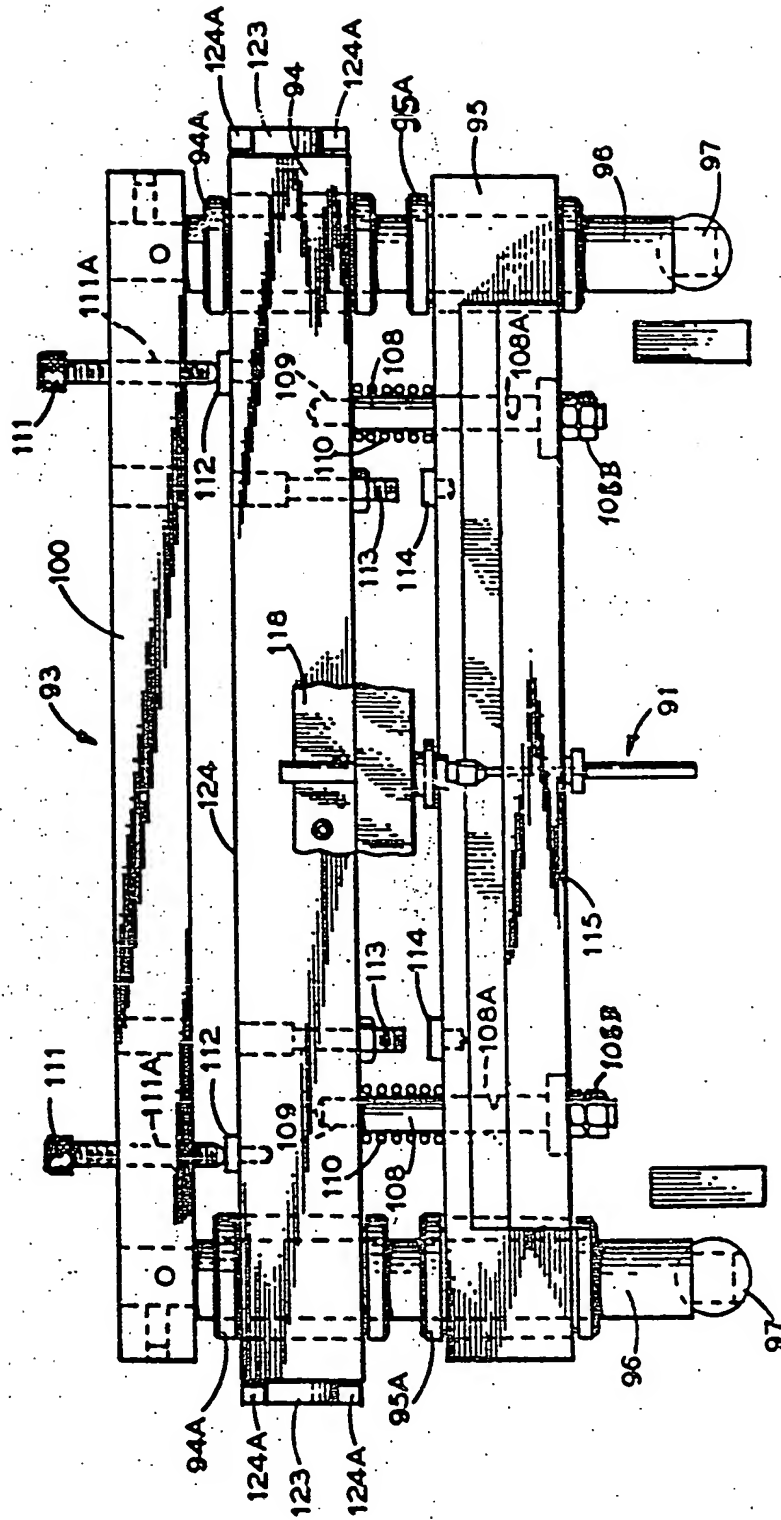


FIG. 27

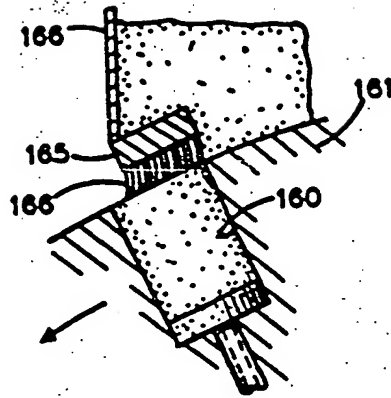


FIG. 28

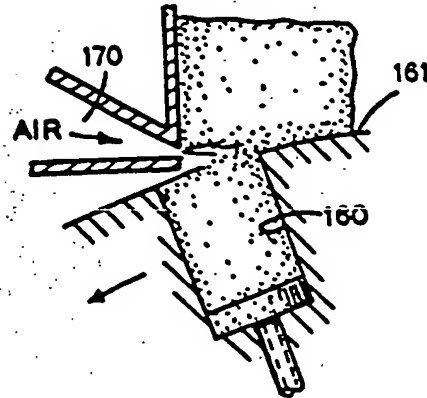


FIG. 29

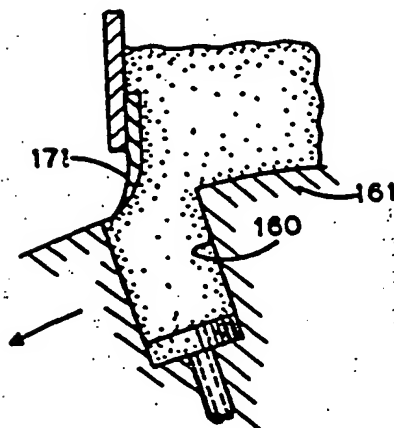


FIG. 30

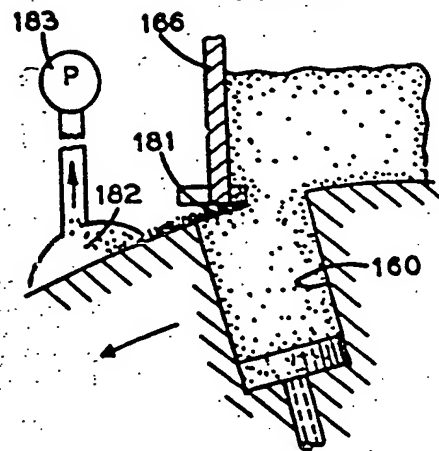


FIG. 26

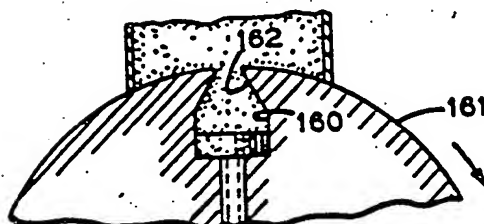
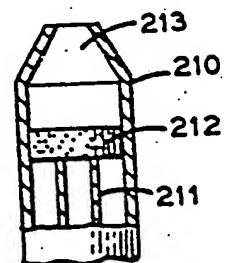


FIG. 33





**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☒ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**